UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Overcoming Obstacles to Widespread EV Charging in Strata-Owned Condos at UBC

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SEEDS Project

Overcoming Obstacles to Widespread EV Charging in Strata-Owned Condos at UBC

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ABBREVIATIONS

Abbreviation	Full-form
BC	British Columbia
CAD	Canadian Dollar
CCA	Capital Cost Allowance
CEEP	Community Energy and Emission Plans
CNG	Compressed Natural Gas
DU	Dwelling Unit
EV	Electric Vehicle
EVCS	Electric Vehicle Charging Station
EVEMS	Electric Vehicle Energy Management System
EVSE	Electric Vehicle Supply Equipment
FSR	Floor Space Ratio
GBA	Gross Building Area
GHG	Greenhouse Gas
KPMH	Kilometre Per Hour
kWH/mWH	Kilowatt Hour/Megawatt Hour
MURB	Multi-Unit Residential Building
OCP	Official Community Plan
O&M	Operations and Maintenance
PEV	Plugin Electric Vehicle
Q2	Quarter 2
REAP	Residential Environmental Assessment Program
sqft	Square Foot
UBC	University of British Columbia
UEL	University Endowment Lands

EXECUTIVE SUMMARY

In the context of a rapid-growing Electric Vehicle Ecosystem in Vancouver, The Wall Group is including Electric Vehicle (EV) charging Infrastructure in new residential developments. To overcome obstacles to widespread in EV charging infrastructure in Strata-owned condos and contributing to sustainability at University of British Columbia, the report is compiled to serve as a handbook for development design teams providing a *set of best practices for metering & allocating ownership of EV charging stations to facilitate EV adoption in residential developments* throughout the Lower Mainland *(ref: REAP credit ID 4.1).*

As the methodology**,** the report provides a thorough compilation of: review of current technical and policy literature, site analysis, study of ownership and cost allocation process, analysis of load management systems, implementation strategy planning and development, and recommendation of policies and metering systems to develop future Residential Environment Assessment Program (REAP) policy.

Discussion: The *International Energy Agency's 2018 Global EV Outlook* study projects that by 2030, the number of electric cars in Vancouver will reach above 70,000 units under current demand-supply and planned policies scenario and; with a high demand scenario, potentially reaching 400,000 vehicles. To accommodate the projected escalation in demand and to create a growing EV ecosystem, the required policy imperatives are assessed including:

- Optimizing EV charging capabilities in new residential and commercial construction
- Deployment of charging infrastructure in existing multi-family dwellings

The featured cases studies *(ref section 4: Case studies),* provide practical insights on development, cost for charging, ownership and load management. This analysis confirms that attaining 100% EV charging readiness for the Multi-Unit Residential Buildings (MURBs) was a result of early planning whereby load and design requirements were considered way in advance. However, the use of all available incentives, increased adoption and minimized development costs, which was exorbitant. Consequently, the total cost of infrastructure development was distributed equally among the residents and for the ease of monitoring and billing of electricity consumption, individual metering systems were found useful**.**

For charging infrastructure, the *Level 2 chargers (ref: section 3.3.1)* have been widely adopted for both residential and shared parking charging stations, and developed to integrate features such as mobile-based access and billing/payment systems. The existing networked and non-networked chargers are based on exclusivity and types of users, which is installed by providers like BC Hydro.

The system has been integrated with Electric Vehicle Energy Management Systems (EVEMS) or load-sharing technology, where chargers communicate with each other on a system and distribute power when multiple stations are being used at one time. The detailed review of the technical standards and technical infrastructure helped in recommending metering and load-sharing best practices discussed in the report.

The supply-chain and cost structure analysis indicates that for a single dedicated unit, the cost for development of energized EV outlets at MURBs include $200-$500 fixed cost per stall, $300-$350 energy cost per year. The equipment cost is approximately $3000 for one time, and the labour cost is about $800 per time.

To give an idea of the price of Level 2 charging equipment, a list of Level 2 charging station manufacturers, local suppliers, and equipment price range is included in this report (R*efer to Section 3.6)*. The prices range from $800 to $12000 which varies by brand and number of users. The manufacturers supply charging stations with data tracking and load management are recommended (i.e. AddEnergie/Flo, BMW).

Recommendations:

Driven by the analysis and insight of industry best practices, the recommendations designed for future REAP framework, in the report are *(ref: section 6.1: RECOMMENDATIONS FOR REAP)*:

- Provide energized Level 2 outlets for 100% of all residential parking stalls in the new MURBs, for all rental and non-rental units.
- Provide energized Level 2 charging stations for at least 25% of visitor parking stalls.
- Deploy EVEMS or electrical load sharing systems with external monitoring for managing demand and tracking individual consumption.

To support the recommendations, the best practices to promote the EV ownership trends in the region are as follows:

- Explore property tax holiday/exemption for builders or developers against expenses incurred in developing EV charging infrastructure in residential buildings
- Subsidies or electricity discounts may be provided against electricity consumption for charging EVs to ease the immediate increase in the average utility bills

Conclusively, these recommendations will contribute in creating an EV ready residential eco-system that rewards early adoption of green alternative transportation (Electric Vehicles) and helps in achieving the carbon reduction targets for the region.

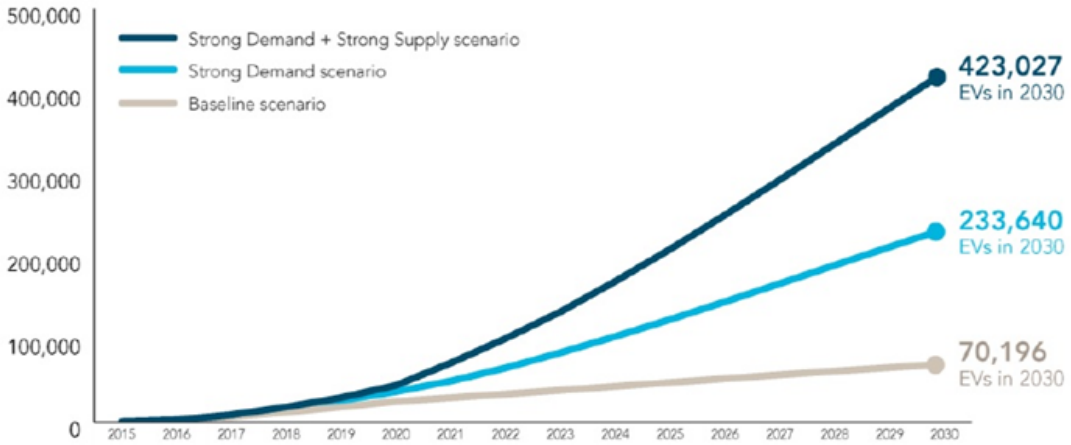
1. INTRODUCTION

The province of British Columbia, where 98% of electricity generation is clean power, Electric vehicles show substantial emissions reduction potential (Richmond, 2018). The electrification of transportation will be an essential component to achieve emission reduction targets set by local, provincial, and federal governments alike. As such, many local governments are now including EV policies and actions in their Official Community Plans (OCPs), Community Energy and Emission Plans (CEEPs), and Transportation Plans.

Contextually, in a broader, comprehensive sustainable transportation strategy, with car-sharing, ride-sharing, and ride-hailing opportunities to reduce the use of privately-owned vehicles, EVs can be a component to support the remaining single-occupancy trips, and help to minimize the community GHG emissions. However, they do not solve other transportation and quality of life challenges such as traffic congestion.

With automotive companies launching electric car models, every year, EV sales are projected to increase in the long term. The International Energy Agency's 2018 Global EV Outlook Projects study; by 2030, the number of Electric Cars in Vancouver will reach above 70,000 units under current demand-supply and planned policies scenario, with modulated demand dynamics, to more than 230,000 and with favourable demand and supply scenario, above 400,000.

Figure 1: Forecasted total EVs in Metro Vancouver by year 2030



Source: BC Hydro, Residential Electric Vehicle Charging: A Guide for Local Governments, 2018

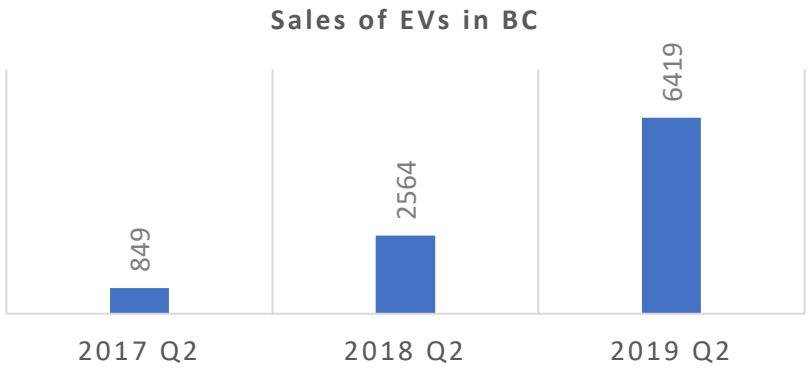
To facilitate the shift towards the ownership of EVs, there has been a gradual change in the regulatory provisions for providing support infrastructure by different municipalities within the region. However, with more than expected growth in the percentage share of new EV car sales, there is a need to revisit these regulatory provisions for providing adequate support to reinforce the move towards cleaner modes of mobility. One prominent support mechanism is

the provisioning of residential chargers and extending convenience to EV owners by residential communities/developers. (Richmond, 2018).

1.1. Rising Trend in Adoption of EVs

The adoption of EVs is growing rapidly in BC. The BC government reported that 9% of all light-duty vehicle sales in BC in the first 9 months of 2019 were EVs[1]. In 2018, the EV segment had witnessed 4% sales in the province. With the increasing trend in EV sales, the corresponding demand for charging stations can be derived to be on the rapid rise for both public and private facilities. In addition, a comparison of Q2 sales for 2018 and 2019 exhibits an increase of over 150% in the province for EVs (Canada, 2019).

Figure 2: Sales trend of EVs between Q2-2016 and Q2-2019 in BC



Source: Electric Mobility Canada, ,Electric Vehicles in Canada Q2 - 2019

1.2. Growth Drivers of EV Adoption

The growth of residential EV adoption is primarily driven by a multitude of factors. Following are some of the major factors responsible for the growth in the sector (Richmond, 2018):

- Availability of EV charging infrastructure or Eco-system
- Innovation in the automobile industry and EVs
- Concerns regarding climate change and environmental pollution
- Favourable government incentives and policies
- Investments in clean energy & reducing emissions

In order to facilitate the higher adoption of EV among users, the province has taken the initiative of making progressive changes to the policies to adopt the EV charging infrastructure in residential units.

[1] (Columbia, 2020)

2. PROJECT BACKGROUND

According to a survey conducted by the City of Richmond (Richmond, 2018), more than 30% of Canadian households are interested in buying a PEV (plug-in electric vehicles) as their next vehicle, but PEVs have only recently surpassed 3% of the new car market share in British Columbia. This indicates there is a significant upcoming demand for charging infrastructure in the foreseeable future for individual charging stations in the residential units.

To provide further momentum to the growth in adoption of EVs, it has been found through industry studies that policies and regulatory provisions are currently key factors. Policy imperatives include the following:

- Requiring EV charging capabilities in new residential and commercial construction
- Supporting deployment of charging infrastructure in existing multi-family dwellings
- Deploying charging infrastructure at public facilities and providing on-street charging opportunities (Richmond, 2018)

2.1. Objectives

Centred on the growing consciousness of reducing carbon emissions and the apparent benefits of owning an electric vehicle for the MURB residents, the objective of this project is to develop a set of best practices for metering and allocating ownership of EV charging stations, to facilitate EV adoption in residential developments at UBC and throughout the Lower Mainland, and to contribute to the development of future UBC REAP versions.

2.2. Scope

In addition to exploring best practices as outlined in the objectives, the scope of this project also entails the following outcomes:

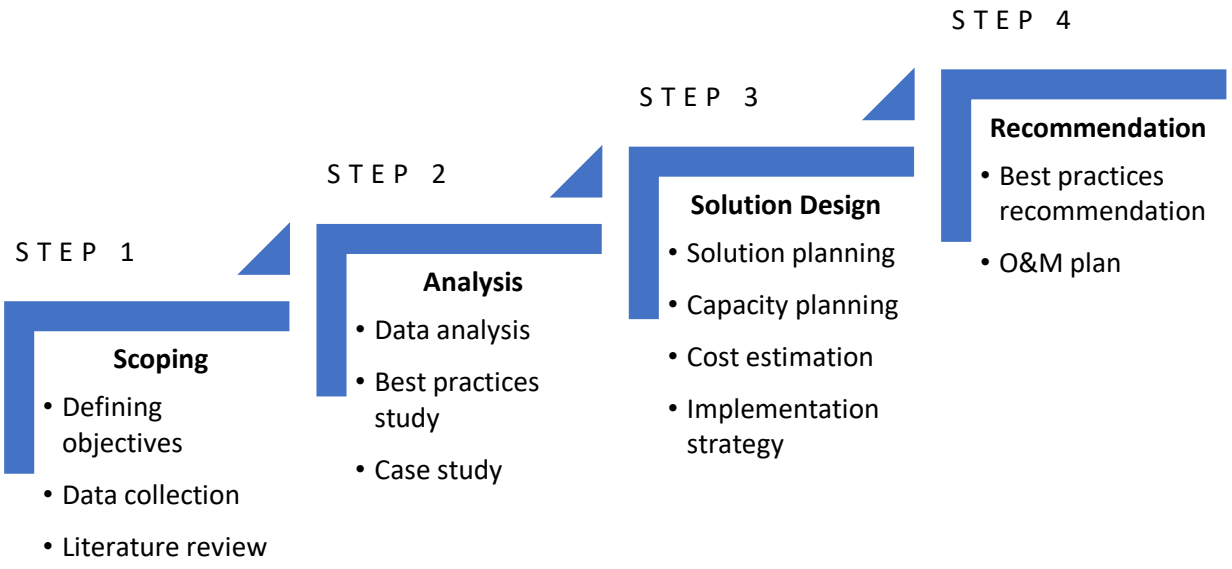
- Review of current residential EV regulations and policies for MURB
- Analyze pros & cons for existing metering models in MURBs
- Review the load management systems to support residential EV charging station
- Explore ownership and cost allocation options for charging stations at strata housing at UBC
- Recommend residential charging implementation models for Wesbrook Village for Level 2 charging stations

2.3. Approach & Methodology

To achieve the project objectives, it is paramount that the scope of the project is well defined and is in concurrence with the goals of the stakeholders. The approach, therefore, follows a scoping exercise, followed by the analysis of data collected from multiple sources, development of options and then the drafting of the final recommendations.

The methods employed for the study include sourcing data through site visits, interactions with the stakeholders, desktop research and developing solutions and recommendations that fit the desired outcomes of the project. The following figure summarizes the approach and methodology for the project.

Figure 3: Approach & methodology for the study



2.4. Limitations

To ensure objectivity of the project, the scope of the project is limited within the set boundaries. This study is, therefore limited by the following:

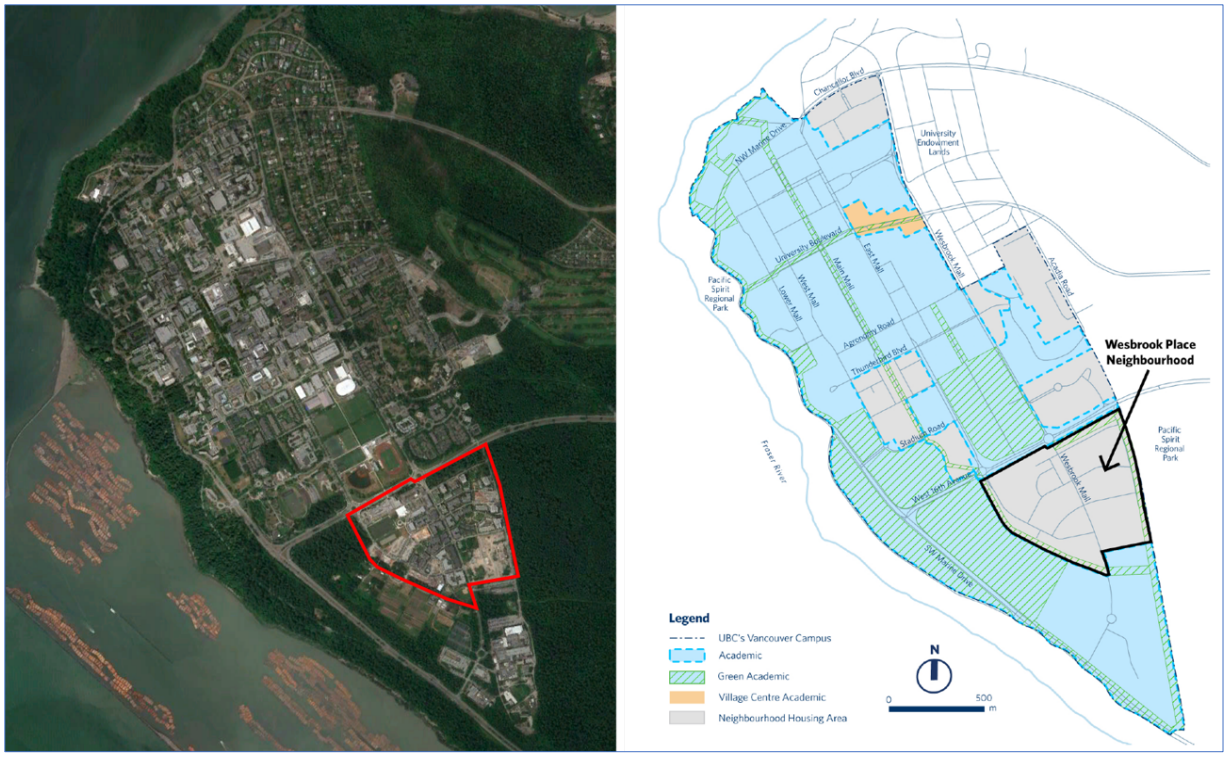
- Analysis and review of EV charging regulations & policies related to MURBs; study of other typologies of residences are excluded;
- Regulatory & policy best practices recommendations may be made only for MURBs within the context of Lower Mainland of Vancouver;
- The study is focused on new MURBs and excludes re-development or retrofitting projects of any kind;
- Ownership and cost allocation recommendations are limited within the context of the UBC Neighbourhood Housing Area.

3. ANALYSIS & ASSESSMENT

3.1. Site Analysis

As part of the main scope, the site selected for the context of this study is Wesbrook Place, located in the southwest part of the UBC Campus, also zoned as a neighbourhood housing area. The reference map is provided below:

Figure 4: Location map of Wesbrook Place



Source: Google Earth and current Land Use Plan for Wesbrook Place

For a general review of the selected area, here we present a brief summary of the overall development. The neighbourhood has 20.7 hectares of net area (excluding public roadways and municipal service areas or public services uses such as day care centres, schools, community facilities, greenways and parks), for the development of residential, commercial and mixed-use buildings, along with a community centre and a school, research and institutional use and, different ancillary uses like a day care facility and other community buildings. It is important to note that this analysis only contemplates the residential new developments.

Table 1: Summary of area per the land-use plan

Total Gross Area	357,570.00	m2	100%	
Net Site Area	207,100.00	m2	58%	
Neighbourhood Open Space	150,470.00	m2	42%	100%
Useable Open Space	104,100.00	m2		69%
Residential Use				
Average Floor Space Ratio	2.68			
Gross Buildable Area	556,000.00	m2		
Number of Units	6,250	un	100%	
Minimun Rental Units	1,250	un	20%	
Persons per Unit	2	p		
Estimated Population	12,500	p		
Commercial Use				
Ground Floor Space Maximum	10,000.00	m2		

Source: Wesbrook Place Neighbourhood Plan, 2005

The net site area represents 58% of the total gross area with 20.71 hectares and the remaining 42% is the open space with 15 hectares, from which almost 70% is usable open space.

In relation to the residential use the Gross Building Area (GBA) generates a Floor Space Ratio (FSR) of 2.68, for 556,000 m2 of gross buildable area, according to the Land Use Plan which states that the FSR has to be between 2.5 and 3.5. It also generally allows 6 stories and 53 metres high buildings, except specific areas shown in the next map. In addition, it dictates that a minimum of 20% of the units need to be rental units, where not less than half of them may include staff, faculty, co-operative, social or other special housing needs.

Figure 5: Wesbrook Place, March 2020

Source: Authors

Commercial and mixed-use buildings are permitted for a maximum of 10,000 sqm. Floor retail space, divided in a neighbourhood grocery which can be up to 3,000 sqm., and the remaining area needs to be divided in small retail stores between 100 sqm. and 350 sqm. In addition, commercial use is limited for only the first two floors.

The residential densities and type of dwellings vary from high, middle, low rise to townhouses, and the permitted storeys vary from 3 story townhouses to 4 to 6 storeys low and middle rise and to 14 to 18 storeys high rise buildings.

As shown in the map below, the high rise buildings are located mostly in the external limits, mainly in the west part of the neighbourhood, allocating the low and mid-high buildings in the rest of the area.

Figure 6: Wesbrook Place Neighbourhood Land-use Plan & FSR

Source: Wesbrook Place Neighbourhood Plan, 2005

Regarding vehicular parking regulations, underground or covered off-street parking would be needed for every building, because street parking is only allowed by means of an additional permit. Vehicular parking standards will comply with the UBC Development Handbook, and shall not exceed the maximum standard dimensions. Minimum parking requirements are for allocating space for accessible, visitor, electric, CNG and shared/coop vehicle parking.

3.2. EV Infrastructure Policies & Regulations

This section refers to the review of prevalent policies and regulations around electric vehicles and charging stations at two levels – Metro Vancouver and University Endowment Lands (UEL). With respect to EV charging facilities in MURBs, UEL land-use bylaw is referred to for directions regarding the sizing of parking provisions (BC, 2020).

3.2.1. Policies in Nearby Municipalities

The comparative summary of existing and previous policies for residential EV infrastructure for municipalities in Lower Mainland Region is provided below:

Table 2: EV infrastructure policies of municipalities in Metro Vancouver

City/Community	Current Policy	Previous Policy
City of Vancouver	Single-family: one energized outlet per parking area (garage, carport). Multi-family: every parking space, excluding visitor, provided with energized outlet, Level 2.	Level 2 (40A, 240V) for 20% of parking stalls in multi-unit residential; all garages/ carports of 1-2 family homes.
City of Burnaby	Every dwelling unit: every required parking space, excluding visitor and secondary suite, provided with energized outlet, Level 2.	Multi-unit residential buildings: negotiated ~10% of parking stalls EV-ready or EVSE installed.
City of Coquitlam	Apartment, townhouse, and street-oriented village home: one energized outlet per dwelling unit, Level 2.	No info available
City of North Vancouver	Single-family: capacity for Level 2 in 100% of parking spaces. Multi-family: 20% of parking spaces supplied by 40A 240V branch circuit. Capacity in the electrical room for 100% of parking spaces.	No info available

City/Community	Current Policy	Previous Policy
City of Port Coquitlam	Every dwelling unit: one stall per residential unit roughed-in (all electrical infrastructure other than wire), Level 2.	No info available
City of Richmond	Every residential parking space, excluding visitor parking, provided with energized outlet, Level 2.	Multi-family parking spaces: 20% provided with 120V receptacle; 25% pre-ducted.
District of North Vancouver	Multi-family: 20% of parking spaces EV-ready, wired for Level 1; conduit for 100%. Secure bicycle storage to include one outlet for electric bicycle charging.	No info available
City of New Westminster	For new buildings that contain at least one dwelling unit, all residential parking spaces and spaces for co-operative vehicles, shall feature an energized Level 2 outlet or higher to the parking space. Energized Level 2 outlets will not be required for visitor parking spaces.	No info available

Source: BC Hydro, Residential Electric Vehicle Charging: A Guide for Local Governments

3.2.2. Local Policies

Local policies that pertain to residential EV charging infrastructure and are applicable in the Wesbrook Place, particularly the Neighbourhood Plan, REAP 3.0 and REAP 3.1 are summarized in the table below:

Table 3: Local EV infrastructure policies applicable at UBC Wesbrook Place

Plan	Category	Policy
Wesbrook Place Neighbourhood Plan	Development control	As the technology for automobile vehicles changes, the infrastructure for on street parking in the neighbourhood should support electric vehicles with re-charging facilities.
	Parking requirement	Governed by REAP 3.1 & UBC Handbook for Development 2018
REAP 3.0	Visitor parking (Optional)	Provide one dedicated parking spot fully equipped with Level 2 charging station per 100 residential units for visitors of residents/owners.

Plan	Category	Policy
	Residential parking (Optional)	Install necessary conduit and transformer capacity to accommodate Level 2 charging stations for the 10%-20% of residents' parking
REAP 3.1	Residential parking - equipment requirement	Provide a minimum of one energized Level 2 outlet per residential unit for non-rental developments or provide energized outlets for 50% of resident parking stalls for rental developments.
	Residential parking - power requirement	Level 2 charging capacity should provide a minimum of 40A service and a minimum performance level of 12 kWh per stall, over an eight-hour period. Load sharing and load management systems may be utilized
	Visitor parking (Optional)	Provide one dedicated parking spot fully equipped with Level 2 charging station per 100 residential units for visitors of residents/owners.
	Residential parking (Optional)	Install necessary conduit and transformer capacity to accommodate Level 2 charging stations for the 5%-10% of residents' parking

Source: Wesbrook Place Neighbourhood Plan 2005, UBC REAP 3.0 & REAP 3.1

3.2.3. Policies & Regulations at Various Levels of Government in Canada

Current residential EV regulations and policies for MURB in the federal, provincial level and local government level (BC, 2020).

Table 4: Federal, provincial & local government policies for EV infrastructure

Levels	Policy	Discussion
Federal	Canadian Tax Code Capital Cost Allowance Classes	Allows for EV charging stations to be classified at a higher rate than previous allowances - Class 43.1 with a CCA rate of 30% electric vehicle charging stations (EVCSs) set up to supply more than 10 kilowatts but less than 90 kilowatts of continuous and Class 43.2 with a CCA rate of 50% electrical vehicle charging stations (EVCSs) set up to supply 90 kilowatts and more of continuous power.
Provincial	British Columbia Strata Property Act	Permits the use of strata common property for residential charging facilities and to allow variable rates for charging users based on

Levels	Policy	Discussion
		consumption to recover expenses as long as it is reasonable and in a bylaw or rule.
	British Columbia Provincial Building Act	Revised to give local governments greater flexibility in making decisions regarding the use of EV charging in new developments.
	British Columbia Ministerial Order M104	Allows those who are not otherwise public utilities, as well as landlords and strata corporations, to provide EV charging services for compensation.
Wesbrook Place Neighbourhood	Wesbrook Place Neighbourhood Plan	Municipalities in the region require 100% of the residential parking stations to be EV-ready in multi-unit residential buildings.
		AES prepared a report for the City of Richmond that recommended a minimum performance level of: 12 KwH per EVSE, over an eight hour overnight period. Load management and/or load sharing may be implemented.

Source: Plugin BC and Wesbrook Place Neighbourhood Plan 2005

3.2.4. Incentives for EV Infrastructure in BC

Table 5: Existing incentive programs include the following

Program	Sponsor	Rebate	Note
CleanBC – Go Electric EV Charger Rebate Program	Government of BC	Constructed prior to municipal bylaws: Up to 50% of purchase and installation costs of eligible, new, Level 2 charging stations or energized outlets to a maximum of $14,000 (up to a maximum of $2,000 per station and up to a maximum of $1,000 per energized outlet). Constructed after municipal bylaws: Up to 50% of purchase and installation costs of eligible, Level 2 charging stations to a maximum of $5,000 (no more than $350 per station).	Pre-approval from BC Hydro is required. If the EV charger rebate program incentive is combined with any other incentive, the total incentives do not exceed the total cost of the equipment and installation.

Program	Sponsor	Rebate	Note
ZapBC	Private sector	Cost of ChargePoint Level 2 charger which can be purchased from London Drugs	Limited number of rebates available each year. Incentives are limited to one per household.

Source: Plugin BC, Fraser Basin Council

3.3. EV Charging Technology

3.3.1. Types of Charging Stations

Currently EVs are powered by three types of chargers, known as Level 1, Level 2 and Level 3 chargers. They are distinguished by the speed of charging capacities and power ratings. Each of the charger types is discussed in brief in the following section. However for the purpose of this study, assessment is conducted only for Level 2 chargers in alignment to the project requirement.

Level 1 Charger	
Level 1 charging uses standard 3-pronged plugs and is designed to draw power from a 110/120 volt domestic power point with dedicated electrical connection or circuit. These charging stations are slow and are mostly suitable for overnight charging. Level 1 chargers usually come with the purchase of all electric vehicles. And the installation costs can vary from $300 to $2500. Level 1 chargers are more suited for infrequent drivers or for hybrids that have smaller battery capacities. With Level 1 chargers, it could take 5 to 20 hours to charge a fully depleted EV battery.	Rating: 120V, 15-20A Voltage: ~1.4kW Range: 5-8 KMPH

Level 2 Charger	
Level 2 charging is the most common and they use a dedicated 208-240 volt power point with dedicated electrical connection or circuit. These chargers offer faster charging speed and have power sources typical to electric ovens and clothes dryers. Suitable for mid-range parking duration – shopping or work type parking. The total cost of installing Level 2 charging can typically range from $6000-$20,000, which includes the cost of the charger and the cost of the installation. Level 2 chargers are suited for higher capacity EV batteries and take 4-8 hours for a full charge. They are highly suitable for purely electric powered vehicles and for longer travel distance requirements.	Rating: 208-240V, 30-40A Voltage: ~7kW Range: 16-30 KMPH

Widely used, Level 2 chargers have been adopted for both residential and shared parking charging stations. They have been developed to integrate additional features such as mobile based access and billing/payment systems. However, they do exist both as networked and non-networked chargers based on exclusivity and types of users.

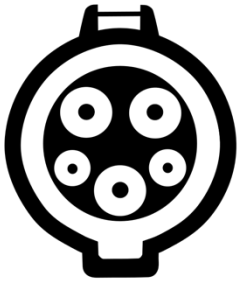
While domestic chargers use single connector types, shared chargers, such as the ones installed by providers like BC Hydro, allow dual port chargers - DCFC and CHAdeMO charge connectors.

Level 2 charging has also been integrated with EVEMS or load-sharing technology where chargers communicate with each other on a system and distribute power when multiple stations are being used at one time. With load sharing, a single 240V, 30A single phase circuit could be used to serve the charging needs of 2-6 parking stalls.

Although this could mean slower charging speed when multiple parking stalls are occupied, it can also mean more efficient use of equipment and significant cost savings.

Level 2 EV charging product is widely available in the market but is supported by a standardized SAE J1772 connector. The only exception is with the Tesla supercharger that is designed with a different type of connector which is compatible to be used with an adapter. The following is a list of different types of Level 2 chargers available in the market currently.

Figure 7: Level 2 charging connector

J-Plug Type 1	Level 2 Connector Port
	

Source: Wikipedia, https://en.wikipedia.org/wiki/SAE_J1772

Level 3 Charger	
Level 3 charging, also known as DC fast charging is the fastest charging type available for EVs and they use 480-600 volt power sources with dedicated electrical connection. Current Level 3 charging stations can cost from $30,000 to more than $50,000 and require additional alteration of electrical circuits and load management in residences. Suitable for short duration high capacity charging or for long-range battery charging. Level 3 chargers offer the closest convenience of refuelling to gas station type experience. They are typically used for purely electric powered vehicles.	Rating: 480-600V, up to 125A Voltage: ~60kW Range: 95-125 KMPH

3.3.2. Charging Equipment

Charging equipment for EV charging can be categorized into three categories:

Partial Electric Vehicles Supply Equipment
– Partially installed electrical infrastructure with, such as the wire, required to be pulled, or the conduit/raceway, outlet, and wire are required to be installed prior to the charging station installation and use – Least costly option at the time of development

– May be used for smaller parking areas, such as smaller townhouse developments – All electrical room equipment should be included in the initial installation – Not recommended due to incurred cost and operational labour to be added in future
Energized Electric Vehicles Supply Equipment
– Electrical equipment including metering, transformers, cabling and associated raceways, and connections (energized outlets) are provided – The EV owner would purchase their own EVSE and have it installed – The development costs are variable, depending on the system configuration – Load sharing using an EVEMS can significantly reduce the costs of providing EV-ready or fully energized outlets to less than 1/3rd the cost of dedicated circuit installation (AES Ltd. 2017. EV Charging Requirement).
Installed Electric vehicle supply equipment
– Electrical equipment including metering, transformers, sub-panels as needed, cabling and associated raceways, and connections – In addition, Level 2 EVSE equipment is installed – This is the easiest option for EV owners – Most costly to install during development

3.4. Energy & Load Management

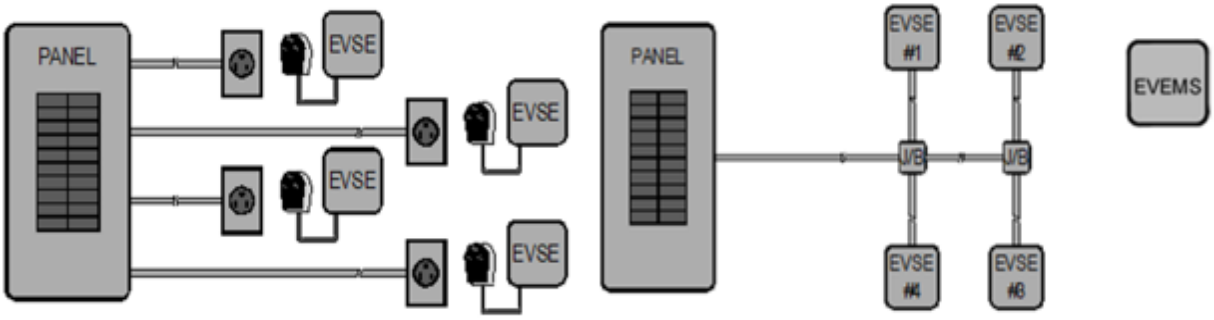
Managing the growing demand of EV charging in MURB also comes with the need to manage the power distribution within the strata properties. Energy/load management for MURBs are developed on load sharing strategies that try to optimize equipment efficiencies. This strategy is also known as power sharing or electric vehicle energy management systems (EVEMS). EVEMS includes clustering of parking stalls and connecting these clusters to a single circuit, which in turn powers 2-4 EVSEs. Advantages of implementing EVEMS include:

- Allows multiple vehicles to be charged with a single circuit
- Reduces capital cost for electrical infrastructure as it reduces number of circuits
- Reduces cost by 45-75% as compared to dedicated Level 2 EVSE connections[2]

In the following figure, the schematic on the left illustrates dedicated EVSE connections, each serving a single EV. The one on right illustrates a clustered 4-way load sharing electrical layout.

[2] *BC Hydro, Residential Electric Vehicle Charging: A Guide for Local Governments*

Figure 8: Dedicated power supply and EVEMS systems



Source: BC Hydro, Residential Electric Vehicle Charging: A Guide for Local Governments

3.4.1. EVEMS without monitoring

EVEMS without monitoring is based on quota based power allocation to each EVSE for a specified time period. Power is supplied from a single circuit and power delivery is based on the actual requirement of each EVSE or proportionately rationed to each EVSE. Through the features inbuilt into the EVEMS, each EVSE determines the individual requirements of an EV and apportions the power accordingly.

Therefore, EVs with lower requirements receive the fixed percentage for a specified time compared to EVs that have greater charging needs, which may receive the remaining available capacity. This load sharing system is built on smart features of the tracking and monitoring systems integrated with the EVEMS.

3.4.2. EVEMS with external monitoring

EVEMS with external monitoring consists of systems to track & regulate demand and supply integrated within the main breaker panels. Energy is supplied based on the type of EV connected to the outlet. Here, a regular off-the -shelf EV charger can be used for charging the EV. It can also be integrated with applications to track individual consumption by using networked systems and allocate billing information to individual users.

Networked EVEMS connect to a communication network – cellular, hard-wired or wireless signals to track different parameters and manage information. They can be used in multiple situations, be it shared parking or for MURBs or single-family homes with multiple parking stalls. However, with networked capabilities, services and O&M responsibilities and charges are needed to be structured for effective administration.

3.5. Cost Structure

The cost structure for development of energized EV outlets at MURBs include the following for a single dedicated unit:

Fixed cost	
Electrical infrastructure cost	$200-500 per stall
Variable cost	
Maintenance cost	Minimal (responsibility of the strata management/ owner)
Energy cost	$300-$350 per year[3]

For EV charging stations for visitor parking, the cost structure is as provided below:

Fixed cost	
Electrical infrastructure cost	$200-500 per stall
Equipment cost	$3000 approx. (one time)
Labour charges	$800 approx. (one time)
Variable cost	
Maintenance cost	Minimal (responsibility of the strata management/ owner)
Energy cost	$300-$350 per year[3]

3.6. Equipment & Suppliers

Below is a list of Level 2 charging station manufacturers, local suppliers and their offered prices based on the online published resources. The list below is for general reference and is not related to any rebate programs. The suppliers listed are shown below, excluding some suppliers that do not have detailed prices shown online.

In some instances you can order a charging station directly from the manufacturer. In other cases, you must go through a supplier. Additionally, some suppliers can also perform the installation of the charging station. For current market prices refer to the links provided in Appendix II.

[3] *BC Hydro, Residential Electric Vehicle Charging: A Guide for Local Governments*

Table 6: Popular charging equipment available in the market

Manufacturers	Suppliers	Brand	Prices (CAD)
Flo	Abstract Energy	Tesla	$800
		Flo	$995-1295
		ChargePoint	$995
		JuiceBox	$895
	Flo	Flo	$795-1095
	Motorize	Flo	$999-1299
		JuiceBox	$979
		Tesla	$1399
	Renegade Electric	Flo	$1211-5023
		Leviton	$2475-11766
	Time to Electrify	Elmec	$799-1219
		Flo	$995-1295
BMW	BMW	BMW	-
Bosch	ChargeHub	EVduty	$799-959
		JuiceBox	-
		Flo	$995-1295
		EV ONE	$800
		Bosch	$839-1299
		EVoInnovate	$829-849
		Sun Country	$1099-1169
	Electrum Charging	Siemens	$1199
	Renegade Electric	Flo	$1211-5023
		Leviton	$2475-11766

Source: Plugin BC, Fraser Basin Council. Details of pricing via https://pluginbc.ca/incentives/manuf_list/

4. CASE STUDIES

This section focuses on three cases that were selected based on building use as Multi-Unit Residential Buildings (MURBs), the number of EV charging stations/outlets provided to meet the changing demand, technical aspects on infrastructure development and load management, information on costs encountered and incentives used for infrastructure development.

However, some information regarding operational and maintenance costs and incentives were missing from the sources.

4.1. Case Study 1

4.1.1. Fifth & West Residences at 501 West Avenue in Downtown Austin, Texas

Location Map
Source: Google Maps

Fifth & West Residences 3D Image
Source: Austin Energy; Green Buildings

This project is a 39 storeys residential building with 154 condo units is one of the best case studies due to its 100% electric vehicle charging readiness. All its 277 resident parking spaces are ready for EV charging stations (Building, 2019).

The parking garage was divided into EV infrastructure zones. A junction box that was designed to provide service to each zone was centrally located and in addition, 150 kVA was installed to supplement the excess capacity to provide a total service capacity of 300kVA dedicated to EV charging.

Condo owners are eligible to receive a residential charging station rebate from Austin Energy to help offset installation costs.

Residents purchase an EV charging station, run conduit and wire to the nearest junction box, and purchase the sub-meter. The sub-meter reads the electric consumption of their charging station and ties into the building management system. Residents are then billed for electric consumption of both their condo unit and parking spot.

4.2. Case Study 2

4.2.1. City Front Terrace in the Marina District of downtown San Diego, California

Location Map
Source: Google Maps

City Front Terrace, 3D Image
Source:http://www.bcre.com/cityfront-terrace-san-diego.php

This project is a 13 storeys mid-rise residential community with over 300 condominium residences. Some tenants began to inquire about EV charging stations for electric vehicles they were planning to purchase in 2011. (Pointon. J, Multi-Unit Dwelling (MuD) Vehicle Charging Case Studies, 2013).

The underground assigned parking spaces were far from the individual electric meter (at the upper floors) and the common area meters. Therefore, the property manager, homeowners association and residents all worked together for a lower charging cost solution, individual billing and flexibility of charging units for each resident.

Finally, 20 individual meters were wired directly to the utility side of the building electrical supply through one of the main buses. Wiring hubs were provided on each floor of the parking garage to allow for wiring to individual parking places. Residents would receive their monthly bill directly from San Diego Gas & Electric.

Each individual requesting vehicle charging would pay an equal portion of the upfront capital expenditure for the project (which was estimated at $80,000) and purchase their own charging unit for installation in their parking space.

4.3. Case Study 3

4.3.1. Silver Spur Court Condos at Rolling Hills Estates in Southern California

Location Map
Source: Google Maps

Silver Spur Court Condos, 3D Image
Source:https://www.mparchitects.com/site/projects/silver-spur-court

This project is a 18-unit condominium property, it is a good case demonstrating how condo owners and residents can work together to provide a 100% EV charging solution while taking advantage of the available incentives (Edison, 2019).

The Silver Spur Court homeowner association president explored all EV charging options after the two residents raised inquiries. He then came across Southern California Edison's (SCE) Charge Ready program details on financial incentives and technical assistance on similar projects. The SCE through Charge Ready program later made all the infrastructure upgrades including installation of a free transformer and so lowered the cost.

The project was implemented in two phases; charge 10 ports on the first level for phase one and 17 charge ports on the second level for phase two. The first phase allowed the residents to share the charging ports with long cables and well-positioned to serve for two. That way the individual cost was lowered.

4.4. Case Study Insights

4.4.1. Development

From the most successful cases, in order to reach the "100% EV charging" ready target, advance planning and consideration from the design stage is necessary. Decisions on infrastructure zoning, location for power source and load requirement were established to guide one-time preparation. Condo owners took advantage of all the available incentives to prepare the infrastructure to allow residents to install charging stations whenever required. Installation phasing has also proved successful in terms of effective cost allocation.

4.4.2. Cost for Charging

The infrastructure costs were distributed equally to all residents who wanted to install the charging stations. With the CityFront Terrace case, the total cost for infrastructure setup was estimated at $80,000 and therefore each resident had to pay $4000 and purchase their own charging unit. However, with different incentives, costs were reduced in some cases.

4.4.3. Ownership

The charging stations and meters in all the cases belong to the residents. Only the infrastructure belongs to the condo owners. Residents were billed for electricity consumption of both the condo unit and the parking charging station.

4.4.4. Load Management

From the Fifth and West residences, the 150kVA transformer was installed as a supplemental solution to the estimated high load demand.

5. PLANNING & DEVELOPMENT

This section discusses the planning and development requirements of residential EV charging infrastructure at Wesbrook Place. Demand estimations are made corresponding to the land-use plan and the time horizon specified in the Wesbrook Place Neighbourhood Plan. Estimations are made with the following considerations:

- The Neighbourhood Plan specifies that annual average permits for residential units will be no more than 400 units in the area (Wesbrook Place Neighbourhood Plan, 2005)
- Aligning to the best practices case studies, provisioning of 100 percent coverage of all future residential parking stalls developed in the neighbourhood
- It will also help the developers provide future ready condos with high perception of market value and standardized and non-discriminatory products

5.1. Demand Estimation – Parking Stalls

Demand estimation for the number of EV parking stall requirements is guided by the parking guidelines of the UBC REAP 3.1 and the UBC Handbook for Development 2018. REAP 3.1 states that for every private dwelling unit, a parking stall has to be provisioned within the building premises. In case of rental units, for every dwelling unit, 0.5 parking stall has to be provisioned. The ratio of non-rental to rental units would be 80:20.

Detailed calculation is provided below:

Description	Quantity
Average annual increase in dwelling units (DU)	400
Number of non-rental units .....A	320
Number of rental units .....B	80
Required EV stalls per unit (average unit size @1000 sqft) C	2
Total EV parking stalls ((A+B)*C)	800
Total residential EV parking stalls developed annually	**800**

Providing 100 percent EV ready parking stalls for both rental and non-rental units will add 800 EV ready parking stalls annually at the neighbourhood.

5.2. Demand Estimation – Power Load

REAP 3.1 states that in addition to the mandatory Level 2 outlet, for every EV ready parking stall, a minimum performance level of 12 kWH over a charging period of 8 hours has to be ensured. Using these conditions laid down by REAP 3.1, estimations for the power demand is provided below:

Description	Quantity
Total residential EV parking stalls developed annually …….A	800
Average daily power requirement per EV parking stall …….B	12 kWH
Average daily power demand (A*B) …….C	9600 kWH
Average monthly power demand (C*30)	288,000 kWH

Therefore, the average monthly power demand in the neighbourhood is expected to increase by 288 mWH for every 400 units of residential units added. However, the actual increase in energy consumption will depend on the EV ownership pattern and is expected to be much lower in the short-term because only a smaller percentage of the new residents is expected to own EVs.

Further, when load sharing strategies are deployed, there is scope for reducing the effective energy demand further.

For context, based on the existing average monthly power consumption of 1640 kWH per month for a 1000 sqft unit, each household will witness an increased power consumption of 360 kWH per month per vehicle. This is a 22 percent increase in monthly consumption.

5.3. Development Planning

Planning Considerations for installing charging stations include looking into the demand drivers and factors that influence infrastructure development planning. These include the consideration of the following sequential steps:

1	**Planning the electrical capacity in the residential buildings/ MURBs**
	The electrical system for the MURB must be designed to provide sufficient capacity to allow for EVEMS panels with clustering of 4 stalls. Capacity can be planned in phases for 100% coverage over a period of time depending on EV adoption projections.

2	**Obtaining permissions and meeting standards** Permits for all construction should be acquired from the BC Safety Authority and/or local authorities in relation to parking provisions and residential EV charging stations. This will ensure adequate measures for supplying equitable power to all users and adherence to construction codes.
3	**Installation of equipment and setting up of monitoring systems** Installation of equipment should follow inspections by engineers and integrated service providers to develop an appropriate design for deployment of EVEMS, designing circuits, and for network connections to provide integrated services like tracking usage, billing, etc.
4	**Accounting of energy consumption and allocation of cost** Create a separate utility account with metering only for EVSE facilities as permitted by BC Hydro. To allocate cost based on consumption, separate sub-meters should be integrated with EVSEs for tracking individual consumption or energy. Alternatively, costs can be allocated directly to individual domestic connections using meters at the EVCS.
5	**Consumption administration and development of O&M plans** Structure the role of strata owners and individuals with regards to O&M of EVSE and electrical equipment and network connections. Make it simple for strata owners to administer future maintenance, upgrades etc.

5.4. Implementation Challenges

While there are many benefits associated with hosting and promoting EVCS, there are some significant barriers that must be addressed.

- Prevalence or continuity of incentives and impact of incentives
- Adoption and utility of the infrastructure – uncertainty in actual energy demand
- Ability to incorporate a combination of EV types in a cluster to reduce net energy demand
- Implementation of consumption tracking & billing will demand additional resources from strata management/property owners
- Need for strong O&M policies and strata by-laws will have to be developed

6. RECOMMENDATIONS & CONCLUSIONS

6.1. Recommendations for REAP

On the basis of our analysis and insights from prevalent best practices, we have developed our recommendations as criteria for development in alignment with existing REAP framework. Points may be assigned on incorporation of these recommendations as REAP criteria. The recommendations are:

Table 7: Recommendations for UBC REAP

SS Mandatory: EV Charging - Resident
Requirement Provide energized Level 2 outlets for 100% of all residential parking stalls in the new MURBs, for all rental and non-rental units.
Intent To motivate EV ownership instead of traditional combustion engine driven cars and reduce the amount of GHG emissions.
Rationale Electric vehicles can reduce GHG emissions from vehicle operation by approximately 28%[4] as compared to conventional petroleum-powered vehicles.
Strategies The strata management/property owner may provide the EV owners with sub-meters connected to the parking stall for tracking & billing of power consumption once they purchase an EV.
SS Mandatory: EV Charging - Visitor
Requirement Provide energized Level 2 charging stations for at least 25% of visitor parking stalls.
Intent To reduce the amount of GHG emissions by traditional combustion engine driven vehicles and encourage the use of electric vehicles.

[4] UBC REAP 3.1

Rationale

Electric vehicles can reduce GHG emissions from vehicle operation by approximately 28%[4] as compared to conventional petroleum-powered vehicles.

The progressive approach towards provision of the EV charging infrastructure that is energized and EV ready for the visitors, will support the adoption and maintenance of the EV ecosystem.

Strategies

The independent, load monitoring and billing strategy supported by smart meters for all EVSE ready charging stations/stalls will facilitate the proper billing of the usage by the visitor vehicles.

SS Mandatory: EVEMS and load sharing systems

Requirement

Deploy EVEMS or electrical load sharing systems with external monitoring for managing demand and tracking individual consumption.

Intent

To increase efficiency in energy consumption and equitable allocation of cost.

Rationale

Developing 100 percent of EV-ready parking stalls will increase the total energy consumption once the number of EVs increase in the properties. EVEMS will help regulate the power demand & supply based on the required amount by the vehicles and reduce excess demand.

Strategies

Load sharing and management of at least 4-way charging should be implemented because this provides an optimum balance between minimum power requirement and initial cost for development of charging facilities (AES Ltd. 2017. EV Charging Requirement).

6.2. Recommendations for the Lower Mainland Region

The aforementioned recommendations may be considered to be applied in the Lower Mainland Region. In addition, following best practices may also be deployed to catalyse the EV ownership trends in the region:

- Explore property tax holiday/exemption for builders or developers against expenses incurred in developing EV charging infrastructure in residential buildings
- Subsidies or electricity discounts may be provided against electricity consumption for charging EVs to ease the immediate increase in the average utility bills

The initiatives developed hereafter, may also be supported with awareness campaigns by agencies responsible for the regulation and implementation of the initiatives.

6.3. Conclusion

The growing trend of EV ownership resulting from global and local carbon emission reduction initiatives needs to align with supporting infrastructure systems. EV charging systems at the multi-unit residential buildings are the basis for residents' motivation towards EV adoption. Revising development standards and guidelines will mandate that all future property developments are ready for the future needs. At the same time providing potential EV owners a readily accessible EV eco-system will motivate faster adoption of EVs.

However, with increased adoption, it is inevitable that there will be increase in demand for power supply. From our assessment, the increase in power demand will be significant and households will witness increases in their utility bills. To provide support, favourable policies in the form of financial incentives and discounts in user fees should be extensively explored to reinforce the positive behaviour.

Strong initiatives and guidelines like the REAP that look into the proactive creation of an EV ready eco-system should be expanded for a widespread effect. And policies that reward early adoption and behavioural should be evaluated and implemented in the region to achieve the carbon reduction and catalyse the growth of cleaner mobility behaviour.

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APPENDIX

Appendix I: Residential Environment Assessment Program

REAP is a sustainability framework developed by UBC as a framework for mandating and measuring sustainability in the development of MURBs in the UBC Neighbourhood Housing Areas. All persons developing multi-family residential projects in any of UBC's Neighbourhood Housing Areas must participate in REAP and achieve at least a REAP Gold Certification, which means achieving all of the mandatory credits and earning at least 35 points from the option credits.

As such, REAP also accounts for provisions of EV charging stations in the neighbourhood – both at parking spots and the residential buildings. With respect to the requirement of EV charging facilities, REAP 3.1 sets the following conditions to meet with its sustainability standards, significantly improving from the previous version:

Requirement	REAP 3.0	REAP 3.1
Volume requirement – Visitors	Optional	Optional
	One dedicated parking spot with fully equipped with Level 2 charging station should be provided per 100 residential units for visitors of residents/owners	One dedicated parking spot with fully equipped with Level 2 charging station should be provided per 100 residential units for visitors of residents/owners
Volume requirement – Residents	Optional	Optional
	Sufficient conduit and transformer capacity should be installed to accommodate Level 2 charging stations for 10% - 20% of residents' parking	Level 2 charging stations should be installed for the 5% - 10% of residents' parking
Equipment requirement		At least one energized Level 2 outlet should be provided per residential unit for non-rental developments, or energized outlets should be provided for 50% of resident parking stalls for rental developments

Requirement	REAP 3.0	REAP 3.1
Power requirement		Level 2 charging capacity should provide a minimum of 40A service and a minimum performance level of 12 kWh per stall, over an eight-hour period. Load sharing and load management systems may be utilized

Appendix II: Link to Charging Equipment Prices

More local manufacturers and suppliers can be found on the PlugIn BC website.

1. Abstract Energy

   (Website: https://www.abstractenergy.ca/)

2. Flo

   (Website: https://www.flo.com/en-CA/)

3. Motorize

   (Website: https://motorize.ca/)

4. Renegade Electric

   (Website: http://renegadeelectricsupply.com/)

5. Time to Electrify

   (Website: http://www.timetoelectrify.ca/shop/)

6. BMW

   (Website: https://charging.bmwgroup.com/web/360electric-international/home-charging)

7. ChargeHub

   (Website: https://can-store.chargehub.com/)

8. Electrum Charging

   (Website: https://www.electrumcharging.com/)

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